THE UNIVERSITY OF CHICAGO

Higgsed dark photons without isocurvatures

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Introduction

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- Higgsed $U(1)$'s with "light" Higgs cannot be fully populated via GPP

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- Stabilizes A and prevents kinetic mixing

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$$\frac{\rho_\sigma}{\rho_\gamma}\Big|_{\text{decay}} = \left(\frac{\sigma_0^2}{6M_{\text{pl}}^2}\right)^{\frac{4}{3}}\left(\frac{M_\sigma}{\Gamma_\sigma}\right)^{\frac{2}{3}} \equiv \mathcal{Q}$$

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- Curvaton also sets the curvature perturbations

$$\mathcal{P}_\zeta = \frac{4}{9}\frac{H_*^2}{4\pi^2\sigma_0^2}, \mathcal{P}_T = \frac{2}{\pi^2}\frac{H_*^2}{M_{\rm pl}^2}$$

$$r = \frac{\mathcal{P}_T}{\mathcal{P}_\zeta} = 18\frac{\sigma_0^2}{M_{\rm pl}^2}$$

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- Since we assume curvaton domination, relevant parameters:

$$\left.\frac{\rho_\sigma}{s}\right|_{T_R}, \mathcal{B} = \frac{\Gamma_{\mathrm{DM}}}{\Gamma_{\mathrm{SM}} + \Gamma_{\mathrm{DM}}}, M_A, M_\sigma$$

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$$\frac{\rho_{\mathrm{DM}}}{s} = \frac{2M_A}{M_\sigma}\,\mathcal{B}\left.\frac{\rho_\sigma}{s}\right|_{T_R}$$

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$$\frac{\rho_{\mathrm{DM}}}{s} = \frac{2M_A}{M_\sigma}\,\mathcal{B}\left.\frac{\rho_\sigma}{s}\right|_{T_R} = \frac{2M_A}{M_\sigma}\frac{\mathcal{B}}{1-\mathcal{B}}\left.\frac{\rho_{\mathrm{SM}}}{s}\right|_{T_R} \approx \frac{2M_A}{M_\sigma}\frac{\mathcal{B}}{1-\mathcal{B}}\frac{3}{4}T_R$$

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$$f_\sigma = \frac{\rho_\sigma}{\rho_\gamma + \frac{1}{3}\rho_\gamma + \rho_\sigma} = \frac{3\rho_\sigma}{4\rho_\gamma + 3\rho_\sigma} = \frac{3\mathcal{Q}}{4 + 3\mathcal{Q}}$$

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- If the curvaton dominates the energy density at decay, ($\mathcal{Q} \equiv \frac{\rho_\sigma}{\rho_\gamma} \gg 1$),

$$\zeta = f_\sigma \zeta_\sigma + \mathcal{O}\left(\frac{1}{\mathcal{Q}^2}\right)$$

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- Since DM is primarily produced via curvaton decay: $\zeta_{\mathrm{DM}} \approx \zeta_\sigma$

$$\mathcal{S}_{\mathrm{DM}} = 3(\zeta_{\mathrm{DM}} - \zeta) \approx 3(\zeta_\sigma - f_\sigma \zeta_\sigma) = 3(1 - f_\sigma)\zeta_\sigma = \frac{3(1 - f_\sigma)}{f_\sigma}\zeta$$

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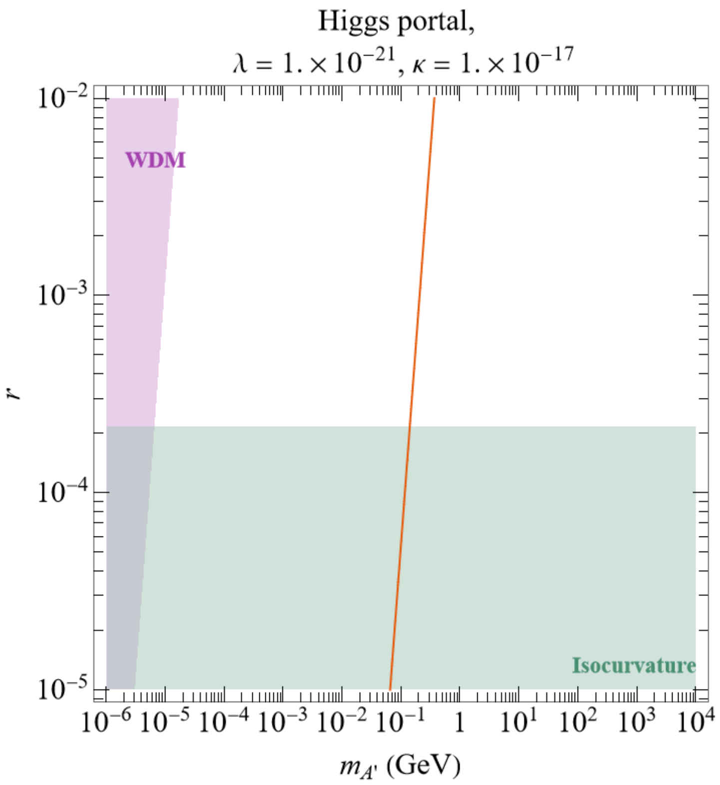
- For isocurvature fully correlated with adiabatic perturbations

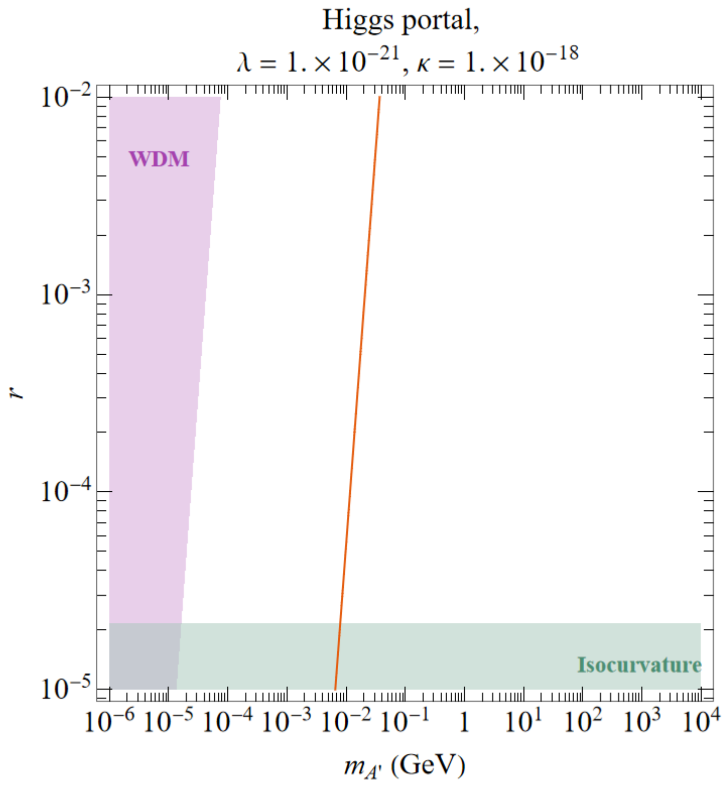
$$\frac{\mathcal{S}_{\mathrm{DM}}}{\zeta} = \frac{4}{Q} \lesssim 0.03$$

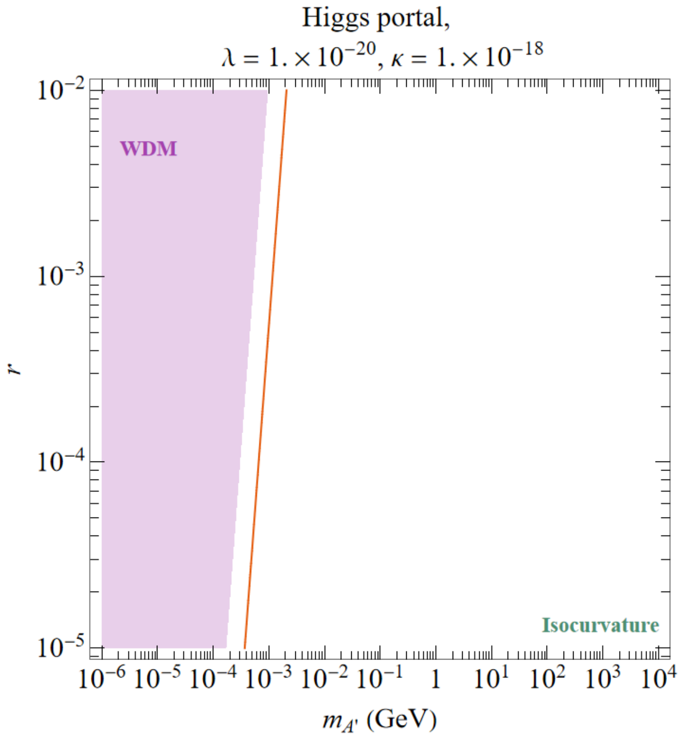
Example

- Consider a Higgs portal:

$$\mathcal{L}_{\text{portal}} = -\kappa|\Phi|^2|H|^2$$







(Preliminary)

Assumes $\sigma_0 \sim f$

Summary

- Higgsed $U(1)$'s with "light" Higgs cannot be populated via GPP without large isocurvatures
- By identifying the Higgs mode as a curvaton, dark sector can still be populated